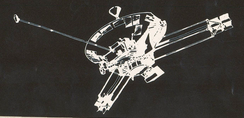
NASA FACTS

AN EDUCATIONAL PUBLICATION OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NF-50 8/74

The JUPITER PIONEERS



Beyond the rocky perimeter of the asteroid belt, hundreds of millions of miles from the Sun, lies the outer solar system—a region of gigantic and mysterious planets.

● Saturn, spectacularly ringed with dust or ice, 10 times larger than Earth, but so light that it could float on water.

● Uranus, a mammoth ball of poisonous gases, spinning on its side.

● Neptune, so distant that it can be seen only as a star-like sparkle, even through the most powerful Earth telescopes.

● Pluto, at the very edge of the solar system, frigid and dark, half the size of the Earth, a dwarf planet in the company of giants.

● And Jupiter, king of the planets, big and bizarre, belted with the rushing yellow-orange, red and gray-blue cloud currents of its incredibly murky and turbulent atmosphere, so deep that no one knows where it ends.

Jupiter seems in some ways to be more a star than a planet. Like our Sun and other stars, it gives off more energy than it receives. It has more than twice the mass of all the other planets combined. The Jovian system is almost a solar system in miniature, with a dozen satellites swirling around.

In 1973, man began the exploration of the outer planets. Pioneer 10 became the first spacecraft to travel beyond Mars, completing the 21-month, 998-million kilometer (620-million mile) trip to Jupiter in December, and then heading for the outer reaches of the solar system and into interstellar space.

En route to Jupiter, Pioneer penetrated the previously unexplored asteroid belt without mishap. Extending between Mars and Jupiter, the asteroid belt is composed of thousands of orbiting fragments of rock and metal, perhaps pieces of a shattered planet. The belt, 280 million kilometers (175 million miles) across, is 80 million kilometers (50 million miles) thick. The safe passage of Pioneer 10 eliminated the long-held fear that high-speed particles from the belt might penetrate the spacecraft and do serious damage.

At the planet, Pioneer discovered a new kind of planetary magnetic field and radiation belt, and many unexpected characteristics of Jupiter and its moons.

A sister spacecraft, Pioneer 11, which completed its long voyage to Jupiter in December 1974, will go on to Saturn, 640 million kilometers (400 million miles) farther away, arriving in 1977.

To make these epic journeys, planners at NASA's Ames Research Center specified relatively fragile and tiny, 259-kilogram (570-pound), semi-intelligent machines. These craft can perform many complex flight functions. They carry 12 scientific instruments to answer 20 major scientific questions.

Pioneer 10 is now on a path that will cause the spacecraft to leave the solar system and wander endlessly throughout the Milky Way galaxy. Both Pioneers carry a message for possible extraterrestrial beings.

The Pioneers generate their own nuclear-electric power. Responding to radio commands from Earth, they communicate as far as 3 billion kilometers (2 billion miles); they maneuver in space, constantly looking back at Earth. They keep precise time, maintain temperature, store data, and do many other jobs. Their instruments study Jupiter's atmosphere and radiation belts, and provide us with clues about the planet's interior. They return pictures of Jupiter and its four inner moons, Europa, Ganymede, Callisto, and Io. The Pioneers are describing the Sun's atmosphere (one source of Earth's weather) out to Uranus' orbit, 3 billion kilometers (2 billion miles) from the Sun.

Through the Pioneer Jupiters, man for the first time is getting a closeup glimpse of the mysterious outer planets. The information returned by these small but hardy spacecraft may help provide new answers to old questions about the origin and evolution of the solar system. This, in turn, will help us to better understand our own home planet and its probable future.

☆GPO : 1974 : O—550-813

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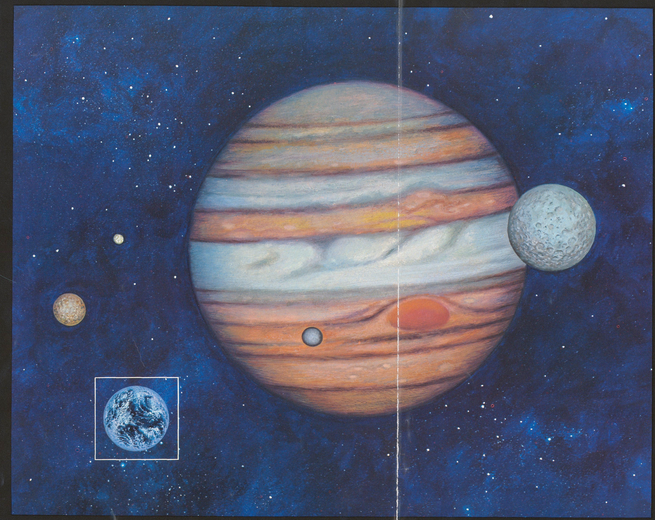
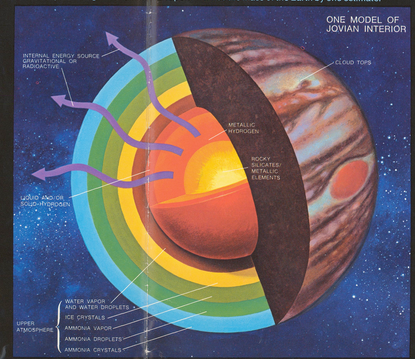
Each Pioneer carries 29 kilograms (65 pound) of scientific instruments. The spacecraft are stabilized in space by constantly rotating five revolutions a minute. Communications and orientation are maintained by narrow-beam, high-gain dish antennas, which point constantly at Earth. The spacecraft can return 1,024 data bits (units of information) per second from Jupiter and store about 50,000 data bits for later transmission. At the distance of Jupiter, radio messages, moving at the speed of light, take 45 minutes to reach the Earth. Electric power is provided by nuclear power sources, located at the ends of two 2.7-meter (9-foot) booms. The spacecraft's eight-watt radio signal transmitted from Jupiter and beyond, reaches Earth antennas with a power of only 1/1,000,000,000,000,000,000 watts. Collected for 19 million years, this energy would light a Christmas tree bulb for only a thousandth of a second.



Spinning majestically through space on its 12-year journey around the Sun, Jupiter is, itself, a solar system in miniature. A dozen satellites swirl around the mother planet. The four inner moons, shown above, were discovered in 1610 by Galileo with his newly-developed telescope. The discovery proved Copernicus' theory of orbital motion of small bodies around large ones. One of the Jovian inner moons, Callisto, is as large as the Earth. The smallest, Io, is as large as the planet Mercury. Earth is shown, in box, approximately to scale.

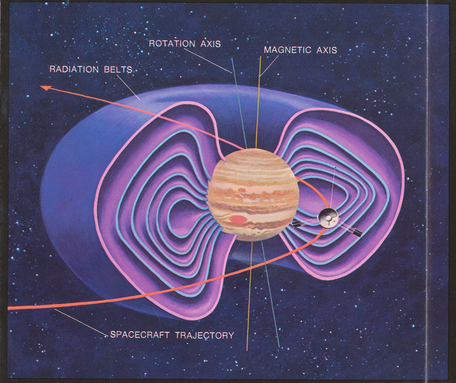
Something most unusual goes on within the murky, turbulent atmosphere of Jupiter. The giant planet gives off two to three times more energy than it receives from the Sun. No one knows why, although gravitational contraction has been suspected as a cause. Temperatures are believed to rise from 93° C (200° F) at the cloud tops to as much as 11,000° C (20,000° F) at the core of the planet. Most proposed models of the planet's structure contain elements like the following: The cloud tops may consist of super-cold ammonia crystals, underlaid by a layer of ammonia droplets, under which may be a region of ammonia vapor.

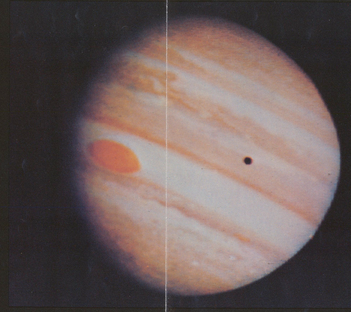
Below this may be layers of ice crystals, water droplets, and water vapor. Below this are either a solid surface or liquid hydrogen oceans. Still lower is a region of metallic hydrogen created by high Jovian gravity, with perhaps a core of rocky silicates and metallic elements. The core might be 10 times the mass of the Earth by one estimate.



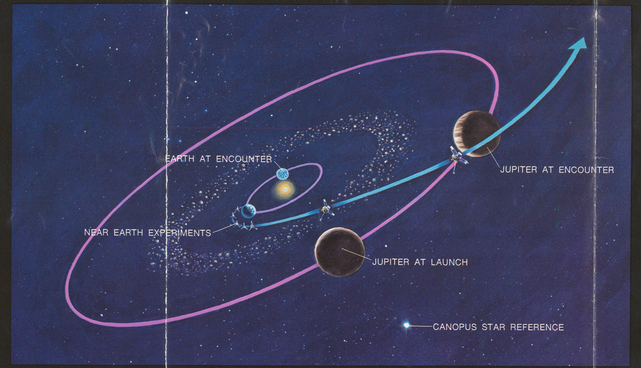
The Pioneers returned man's first closeup pictures of Jupiter. Overlapping pictured areas are shown. The pictures are computer reproductions of digital data, originally recorded in 64 intensities of light. The instrument used was an imaging photopolarimeter (IPP), which, aimed according to preset ground commands, measured Jupiter's intensity every 1/1000th of a second in red and blue light. Intensities were then stored in a spacecraft memory bank and sent to Earth at the rate of about 1000 bits of information per second. Through super-imposition of red and blue elements, two-color images are reconstructed after transmission of the number-coded intensities to Earth.

Earth receives more radio noise from Jupiter than from any source except the Sun. Some of these radio outbursts, in the decameter (10's of meters) wavelength range, equal the power of several hydrogen bombs. Most scientists believe they are the result of huge discharges of electricity (like lightning flashes) in Jupiter's upper atmosphere. Among the nine planets, only Jupiter and Earth are known to have magnetic fields and radiation belts. Jupiter's radio emissions and the Pioneer 10 results indicate the planet's magnetic field is doughnut-shaped with north and south poles like the Earth. It is 20 times stronger than Earth's field, and the concentration of particles (high-energy protons and electrons trapped from the solar wind) is a million times greater than for Earth's radiation belts. Inner regions of the Jupiter belts are a major hazard to spacecraft.

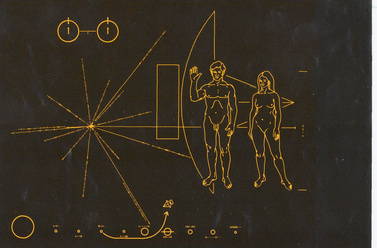




This closeup photograph of Jupiter was taken by Pioneer 10 on Dec. 2, 1973, about 2,540,000 kilometers (1,580,000 miles) from the planet. Black spot is the shadow of the moon Io. The Great Red Spot is at left. Jupiter, largest planet in the solar system, has 1000 times the volume of the Earth.



Using the enormous gravitational pull of Jupiter to whip it past at greatly increased speed, Pioneer 10 headed for the boundaries of the solar system where no man-made craft has ever sailed. Pioneer 10 will cross the orbit of Saturn in 1976, the orbit of Uranus in 1979, and Neptune in 1983. After crossing the orbit of Pluto in 1987, it will become the first man-made object to leave the solar system. Man reached out beyond Mars to take the first close look at Jupiter when Pioneer 10 was launched from Kennedy Space Center, Fla., March 3, 1972. The sister ship, Pioneer 11, began the long voyage a year later. The Pioneers were propelled faster than any man-made object had previously flown, more than 51,000 kilometers (32,000 miles) an hour. The trip to Jupiter lasts nearly two years. Pioneer 10 flew through the dangerous Jupiter radiation belts, 140,000 kilometers (87,000 miles) from the surface, on Dec. 21, 1973. Pioneer 11, which encountered the giant planet in December, 1974, will go on to Saturn.



Pioneer 10 will leave the solar system. This raises the possibility that it could be observed in the far distant future by intelligent beings of another planetary system. As a result, the spacecraft carries a plaque designed to indicate by astronomical symbols, binary numbers and drawings when, where and by what kind of beings the Pioneer was launched. The plaque, of gold-anodized aluminum, is 152 × 229 millimeters (6 × 9 inches) in size.